CBSE Class 12 Physics
Sample Paper 02 (2020-21)

Maximum Marks: 70
Time Allowed: 3 hours

General Instructions:

i. All questions are compulsory. There are 33 questions in all.
ii. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
iii. Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.
iv. There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.

Section A

1. A metal plate is introduced between the plates of a charged parallel plate capacitor. What is its effect on the capacitance of the capacitor?
2. What is meant by the transverse nature of electromagnetic waves?

OR

How is the speed of electromagnetic waves in vacuum determined by the electric and magnetic fields?
3. State the reason, why two independent sources of light cannot be considered as coherent sources.
4. The coils in certain galvanometers have a fixed core made of non-magnetic metallic materials. Why does this oscillating coil come to rest so quickly in such a core?

OR

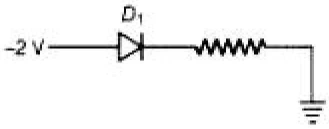
Two parallel conducting wires carrying electric current in the same direction attract each other. Explain, why?

5. When monochromatic light travels from one medium to another, its wavelength changes but frequency remains the same. Explain.
6. Write the relationship of de-Broglie wavelength λ associated with a particle of mass m in terms of its kinetic energy E.
7. Define binding energy of a nucleus.

OR

Which one is unstable among neutron, proton, electron and $\alpha-$ particle.

8. Write the names of majority and minority charge carriers in a p-type semi-conductor?
9. Name the SI units of magnetic flux and magnetic induction.
10. Which type of biasing is there in the following diode?



11. **Assertion (A):** In a simple battery circuit the point at the lowest potential is the positive terminal of the battery.
    Reason (R): The current flows towards the point of the lower potential, as it does in a circuit from negative to the positive terminal.
    a. Both A and R are true and R is the correct explanation of A
    b. Both A and R are true but R is NOT the correct explanation of A
    c. A is true but R is false
    d. A is false and R is also false
12. **Assertion (A):** When a capacitor is charged by a battery, both the plates receive charge equal in magnitude, no matter the sizes of plates are identical or not.
    Reason (R): The charge distribution on the plates of a capacitor is in accordance with the charge conservation principle.
    a. Both A and R are true and R is the correct explanation of A
    b. Both A and R are true but R is NOT the correct explanation of A
    c. A is true but R is false
    d. A is false and R is also false
13. **Assertion:** We cannot get a diffraction patterns from a wide slit illuminated by monochromatic light.

Reason: In the diffraction pattern, all the bright bands are not of the same intensity.

a. Both A and R are true and R is the correct explanation of A
b. Both A and R are true but R is NOT the correct explanation of A
c. A is true but R is false
d. A is false and R is also false

14. **Assertion (A):** In a hydrogen atom, there is only one electron, but its emission spectrum shows many lines.

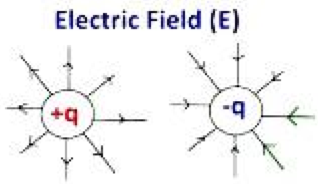
Reason (R): In a given sample of hydrogen, there are many atoms, each containing one electron; hence many electrons in different atoms may be in different orbits, so many transitions from higher to lower orbits are possible.

a. Both A and R are true and R is the correct explanation of A
b. Both A and R are true but R is NOT the correct explanation of A
c. A is true but R is false
d. A is false and R is also false

Section B

15. **Read the source given below and answer any four out of the following questions:**

Electric field intensity at any point is the strength of the electric field at that point. It is also defined as the force experienced by unit positive charge placed at that point. Electric Field Intensity is a vector quantity. It is denoted by 'E'. When placed within the electric field, the test charge will experience an electric force - either attractive or repulsive.



i. The Electric field at a point is
   a. always continuous
   b. continuous if there is no charge at that point
   c. discontinuous only if there is a negative charge at that point
   d. None of these

ii. A charge is distributed uniformly over a ring of radius ‘a’. Obtain an expression for the electric intensity E at a point on the axis of the ring. Hence the points at large distances from the ring, it behaves like a point charge is:
   a. $E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{x^2}$

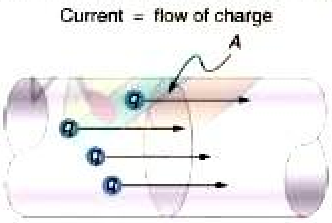
b. $E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{x}$
c. $E = \frac{1}{2\pi\varepsilon_0} \cdot \frac{Q}{x^2}$
d. $E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{x^4}$

iii. Force acting on an electron in a uniform electric field of 5×10^4 N/C is:
   a. 7×10^{-15} N
   b. -7×10^{-15} N
   c. 8×10^{-15} N
   d. -8×10^{-15} N

iv. At a particular point, the electric field depends upon:
   a. source charge Q only
   b. test charge q_0 only
   c. both Q and q
   d. neither Q nor q

v. Four charges of the same magnitude and same sign are placed at the corners of a square, of each side 0.1 m. then electric field intensity at the centre of the square is:
   a. zero
   b. 0.01 N/C
   c. 0.1 N/C
   d. 0.25 N/C

16. **Read the source given below and answer any four out of the following questions:**
The rate of flow of charge through any cross-section of a wire is called electric current flowing through it. Electric current (I) = $\frac{q}{t}$. Its SI unit is ampere (A). The conventional direction of electric current is the direction of motion of positive charge. The current is the same for all cross-sections of a conductor of the non-uniform cross-section. Resistance is a measure of the opposition to current flow in an electrical circuit.



i. An example of non-ohmic resistance is:
   a. tungsten wire
   b. carbon resistance

c. diode
d. copper wire

ii. Current is:
a. scalar quantity
b. vector quantity
c. both scalar and vector quantity
d. none of the above

iii. In a current-carrying conductor, the net charge is:
a. 1.6×10^{-19} coulomb
b. 6.25×10^{-18} coulomb
c. zero
d. infinite

iv. The current which is assumed to be flowing in a circuit from the positive terminal to negative is called:
a. direct current
b. pulsating current
c. conventional current
d. none of these

v. A current passes through a wire of non-uniform cross-section. Which of the following quantities are independent of the cross-section?
a. The charge crossing
b. drift velocity
c. current density
d. free electron density

Section C

17. The ground state energy of hydrogen atom is -13.6 eV. If an electron makes a transition from an energy level -1.51 eV to - 3.4 eV, then calculate the wavelength of the spectral line emitted and name the series of hydrogen spectrum to which it belongs.

18. The image obtained with a convex lens is erect and its length is four times the length of the object. If the focal length of the lens is 20 cm, calculate the object and image distances.

OR

You are given 3 lenses having powers P_1 = 6D, P_2 = 3D, and P_3 = 12D. Which two of these lenses will you select to construct a microscope?

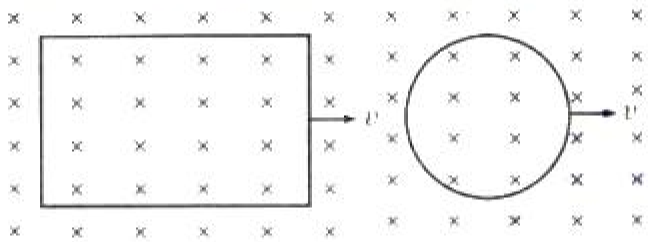
19. There is uniform electric field of $3 \times 10^3 \hat{i}$ NC^{-1}. What is the net flux of the uniform electric field through a cube of side 20 cm oriented so that its faces are parallel to the co-ordinate planes?

OR

Derive an expression for electric field intensity at a point at distance r from a point electric charge.

20. A hydrogen atom initially in the ground level absorbs a photon, which excites it to the n = 4 level. Determine the wavelength and frequency of photon.

21. A rectangular loop and a circular loop are moving out of a uniform magnetic field to a field free region with a constant velocity v as shown in a given figure.



Explain, in which loop do you expect the induced e.m.f. to be constant during the passage out of the region. The magnetic field is normal to the loops.

22. Why is the density of the nucleus more than that of the atom?

23. Define the magnifying power of a compound microscope. Why should both the objective and the eyepiece have small focal lengths in a microscope?

24. A steel wire of length l has a magnetic moment M. It is then bent into a semicircular arc. What is the new magnetic moment?

OR

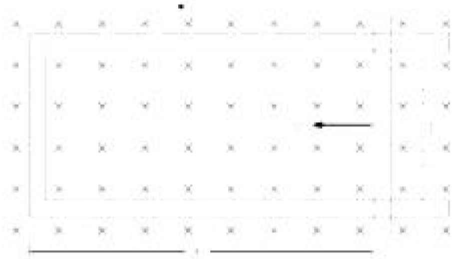
i. Name the three elements of the Earth's magnetic field.
ii. Where on the surface of the Earth is the vertical component of the Earth's magnetic field zero?

25. Show that the least possible distance between an object and its real image in a convex lens is 4f, where f is the focal length of the lens.

Section D

26. i. A rod of length l is moved horizontally with a uniform velocity v in a direction

perpendicular to its length through a region in which a uniform magnetic field is acting vertically downward. Derive the expression for the emf induced across the ends of the rod.



ii. How does one understand this motional emf by invoking the Lorentz force acting on the free charge carriers of the conductor? Explain.

27. i. Explain two features to distinguish between the interference pattern in Young's double slit experiment with the diffraction pattern obtained due to a single slit.

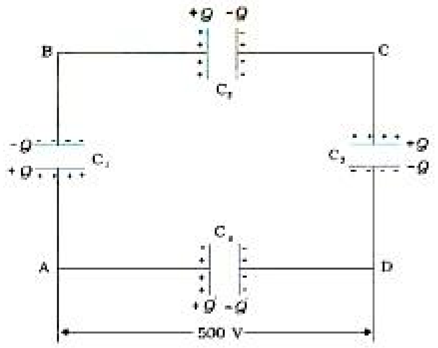
ii. A monochromatic light of wavelength 500 nm is incident normally on a single slit of width 0.2 mm to produce a diffraction pattern. Find the angular width of the central maximum obtained on the screen. Estimate the number of fringes obtained in Young's double slit experiment with fringe width 0.5 mm, which can be accommodated within the region of total angular spread of the central maximum due to the single slit.

OR

i. If one of two identical slits producing interference in Young's experiment is covered with glass, so that the light intensity passing through it is reduced to 50%, find the ratio of the maximum and minimum intensity of the fringe in the interference pattern.

ii. What kind of fringes do you expect to observe if white light is used instead of monochromatic light?

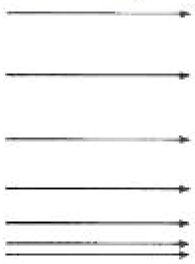
28. A network of four 10 μF capacitors is connected to a 500 V supply, as shown in fig. Determine



a. the equivalent capacitance of the network and
b. the charge on each capacitor.
(Note, the charge on a capacitor is the charge on the plate with higher potential, equal and opposite to the charge on the plate with lower potential.)

OR

Work done to move a charge along a closed path inside an electric field is always zero. Use this fact to prove that it is impossible to produce an electric field in which all the lines of force would be parallel straight lines and the density of their distribution would constantly increase in a direction perpendicular to the lines of force as shown in Figure.



29. i. Describe briefly three experimentally observed features in the phenomenon of photoelectric effect.
ii. Discuss briefly how wave theory of light cannot explain these features.
30. i. A circular coil of 30 turns and radius 8.0 cm, carrying a current of 6.0 A is suspended vertically in a uniform horizontal magnetic field of magnitude 1.0 T. The field lines make an angle of 60° with the normal to the coil. Calculate the magnitude of the counter torque that must be applied to prevent the coil from turning.
ii. Would your answer change if the circular coil in (a) were replaced by a planar coil of some irregular shape that encloses the same area?

Section E

31. State the principle of working of p-n diode as a rectifier. Explain, with help of a circuit diagram, the use of p-n diode as a full wave rectifier.

OR

i. Describe the working of Light Emitting Diodes (LEDs).
ii. Which semiconductors are preferred to make LEDs and why? Give two advantages of using LEDs over conventional incandescent low power lamps.
32. A 2 μF capacitor, 100 Ω resistor and 8 H inductor are connected in series with an AC

source.

i. What should be the frequency of the source such that current drawn in the circuit is maximum? What is this frequency called?
ii. If the peak value of emf of the source is 200 V, find the maximum current.
iii. Draw a graph showing a variation of amplitude of circuit current with changing frequency of applied voltage in a series L-C-R circuit for two different values of resistance R_1 and R_2 ($R_1 > R_2$).
iv. Define the term 'Sharpness of Resonance'. Under what condition, does a circuit become more selective?

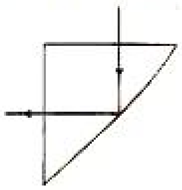
OR

State the principle of an ac generator and explain its working with the help of a labelled diagram. Obtain the expression for the emf induced in a coil having N turns each of cross-sectional area A, rotating with a constant angular speed ω in a magnetic field $\vec{B}$, directed perpendicular to the axis of rotation.

33. i. Define a wavefront. How is it different from a ray?
ii. Depict the shape of a wavefront in each of the following cases.
   a. Light diverging from point source.
   b. Light emerging out of a convex lens when a point source is placed at its focus.
   c. Using Huygen's construction of secondary wavelets, draw a diagram showing the passage of a plane wavefront from a denser into a rarer medium.

OR

A ray of light incident normally on one of the faces of a right angled isosceles prism is found to be totally reflected as shown.



i. What is the minimum value of the refractive index of the material of the prism?
ii. When the prism is immersed in water, trace the path of the emergent ray for the same incident ray indicating the values of all the angles. (μ of water = $\frac{4}{3}$).

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Solution

Section A

1. If a metal plate is introduced between the plates of a charged parallel plate capacitor, then capacitance of parallel plate capacitor will become infinite.
2. Transverse nature of electromagnetic waves means the electric and magnetic fields in an electromagnetic wave are perpendicular to each other and to the direction of propagation.

OR

The speed of electromagnetic waves in vacuum is determined by the electric and magnetic fields by using the formula:
c = $\frac{E_o}{B_o} = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$
where, E_0 and B_0 are maximum electric field and magnetic field components respectively of electromagnetic waves, μ_0 *and* ϵ_0 are permeability and permittivity of vacuum or free space respectively.

3. It is because, the phase difference between the light waves from the two independent sources keeps on changing continuously.
4. The restoring torque due to eddy current in core tries to restore the coil back to its original position and thus brings it quickly to rest.

OR

The current through one conducting wire produces magnetic field and the other parallel current carrying wire experiences force due to this magnetic field. The application of Biot Savart's law tells that when the current in the two wires is in same direction, the two wires attract each other.

5. Because the refractive index for a given pair of media depends on the ratio of wavelengths or velocity of light in two media and not on frequency (because the frequency of light depends on its source).
6. Relation between Kinetic energy and linear momentum is, $K = \frac{p^2}{2m}$

where p = momentum, K = kinetic energy, m = mass

So,

$\Rightarrow \quad p=\sqrt{2mK}$

de-Broglie wavelength, where, p = $\sqrt{2mK}$

$\Rightarrow \quad \lambda=\frac{h}{\sqrt{2mK}}=\frac{h}{\sqrt{2mE}} \quad [as\ K=E]$

7. The binding energy of a nucleus is equal to the amount of work done to separate the nucleons an infinite distance apart from each other, so that they no longer interact with each other.

OR

Neutron is unstable among the four. It decays into proton, electron and an anti-particle called anti-neutrino.

8. **Majority carriers-** Holes

   Minority carriers- Electrons

9. SI units of magnetic flux and magnetic induction are Wb and Wb m^{-2} (or tesla) respectively.
10. Reverse Biasing
11. (d) A is false and R is also false

    Explanation: Both assertion and reason are false. In a simple battery circuit, the point at the lowest potential is the negative terminal of the battery. The current flow in the circuit, from a positive terminal to the negative terminal.
12. (a) Both A and R are true and R is the correct explanation of A

    Explanation: Both A and R are true and R is the correct explanation of A
13. (b) Both A and R are true but R is NOT the correct explanation of A

    Explanation: Both A and R are true but R is NOT the correct explanation of A
14. (a) Both A and R are true and R is the correct explanation of A

    Explanation: Both A and R are true and R is the correct explanation of A

Section B

15. i. (b) continuous if there is no charge at that point

    ii. (a) $\mathrm{E}=\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{x^2}$

    iii. (c) 8 × 10^{-15} N

    iv. (a) source charge Q only

v. (a) Zero

16. i. (c) diode

ii. (a) scalar quantity

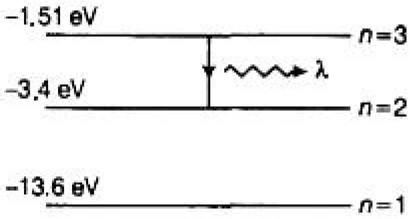
iii. (c) zero

iv. (c) conventional current

v. (d) free electron density

Section C

17. Energy levels of H-atom are ,



We know that, the wavelength of spectral line emitted

$\lambda = hc/\Delta E$

Taking, hc = 1240 eV-nm

We have, ΔE = 1.51 - (-3.4) = 1.89 eV

$\therefore \quad \lambda = \frac{1240}{1.89} \approx 656\text{nm}$

This belongs to Balmer series.

18. Given: Here it is given that, $v = 4u$

By using lens formula, we have

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\frac{1}{f} = \frac{1}{(4u)} - \frac{1}{(u)}$

$\Rightarrow \quad \frac{1}{20} = \frac{1-4}{4u} = \frac{-3}{4u} \Rightarrow u = \frac{-20\times3}{4} = -15\text{cm}$

Hence, v = 4u = -15×4 = -60 cm

Object distance = 15 cm, Image distance from lens = 60 cm

OR

Magnifying power of a microscope,

$m \propto \frac{1}{f_0} \cdot \frac{1}{f_e} \propto P_0 P_e$

Since power and magnification have direct dependence, lens of greater power is required for magnificaton.

Here, we use P_1 = 6D and P_3 = 12D for constructing a microscope.

As $P_0 > P_e$,

$\therefore P_3 = 12D$ should serve as objective lens and $P_1 = 6D$ should serve as eye lens.

19. Here, $\vec{E} = 3 \times 10^3 \hat{i}\ NC^{-1}$

$A = 20 \times 20 = 400\ cm^2 = 4 \times 10^{-2}\ m^2$

Through a face parallel to XY-plane :

$\vec{A}_1 = 4 \times 10^{-2} \hat{k}\ m^2$

$\therefore \phi_1 = \vec{E} \cdot \vec{A_1} = \left(3 \times 10^3 \hat{i}\right) \cdot \left(4 \times 10^{-2} \hat{k}\right) = 0$

Through a face parallel to YZ-plane :

$\vec{A}_2 = 4 \times 10^{-2} \hat{i}\ m^2$

$\therefore \phi_2 = \vec{E} \cdot \vec{A_2} = \left(3 \times 10^3 \hat{i}\right) \cdot \left(4 \times 10^{-2} \hat{i}\right)$

$= 120\ Nm^2\ C^{-1}$

Through a face parallel to ZX-plane :

$\vec{A_3} = 4 \times 10^{-2} \hat{j} m^2$

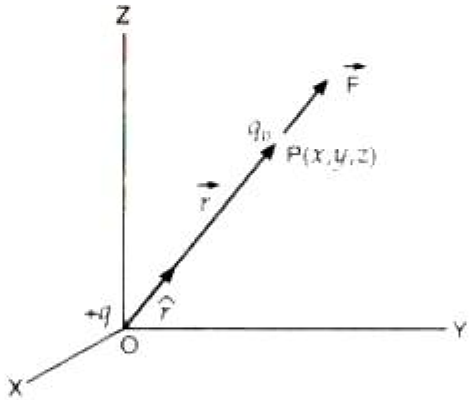
$\therefore \phi_3 = \vec{E} \cdot \vec{A_3} = \left(3 \times 10^3 \hat{i}\right) \cdot \left(4 \times 10^{-2} \hat{j}\right) = 0$

In each plane, there is a set of two faces of the cube. Through one face, electric flux enters and through the other face, an equal flux leaves. Therefore, net flux through the cube,

$\phi = (\phi_1 - \phi_1) + (\phi_2 - \phi_2) + (\phi_3 - \phi_3) = 0$

OR

Consider that a point charge +q is placed at the origin O of the co-ordinate frame. Let P be the point, where electric field due to the point charge +q is to be determined. Let OP = r be the position vector of the point P.



To find electric field at point P, place a vanishingly small positive test charge q_0 at point P.

According to Coulomb's law, force on the test charge q_0 due to charge q is given by

$$\overrightarrow{\mathrm{F}} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qq_0}{r^2}\hat{r}$$

where $\hat{r}$ is unit vector along OP. If $\vec{E}$ is the electric field at point P, then

$$\overrightarrow{\mathrm{E}} = \operatorname*{Lt}_{q_0\to 0} \frac{\overrightarrow{\mathrm{F}}}{q_0} = \operatorname*{Lt}_{q_0\to 0}\left(\frac{1}{q_0} \cdot \frac{1}{4\pi\varepsilon_0} \cdot \frac{qq_0}{r^2}\hat{r}\right)$$

or $\overrightarrow{\mathrm{E}} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^3}\vec{r}$ ....(i)

The magnitude of the electric field at point P is given by

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$

20. Energy of an electron in nth orbit of H atom,

$$E_n = \frac{-13.6}{n^2}eV$$

Thus, E_1 = -13.6 eV

Energy in 4^{th} (n = 4) level,

$$E_4 = \frac{-13.6}{4^2} = -0.85 \text{ eV}$$

Now, $\Delta E = E_4 - E_1$

$$\Delta E = -0.85 - (-13.6)eV$$

$$\Delta E = 12.75eV$$

Thus, $h\nu$ = 12.75 eV

$$h\nu = 12.75 \times 1.6 \times 10^{-19} J$$

$$\nu = \frac{12.75\times1.6\times10^{-19}}{6.6\times10^{-34}}$$

$$\nu = 3.078 \times 10^{15} Hz$$

Thus, $\lambda = \frac{c}{\nu} = \frac{3\times10^8}{3.078\times10^{15}}$

So, $\lambda = 974.4\overset{o}{A}$

21. As the loops move out of the magnetic field, the rate at which the area of the loop decreases inside the field is constant in case of the rectangular loop, while it varies in the case of the circular loop. As a result, the rate of decrease of magnetic flux and hence the induced e.m.f. produced in the rectangular loop will be constant.

22. A nucleus contains neutrons and protons. Its size is of the order of 10^{-15} m. On the other hand, an atom contains neutrons, protons and electrons. The size of the atom is of the order of 10^{-10} m. It means size of the atom is 10^5 times the size of the nucleus. Since mass

of the atom is very slightly greater than the mass of the nucleus, hence the density of the atom is very small as compared to that of the nucleus.

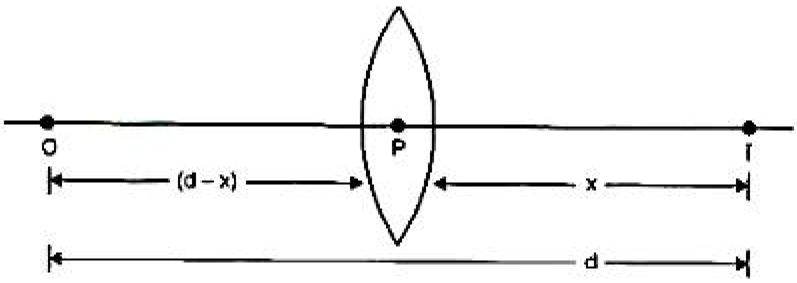
23. The magnifying power of a compound microscope is defined as the ratio of the angle subtended by the final image at the eye to the angle subtended by the object when both are placed at the least distance of distinct vision.
    In a compound microscope, magnifying power = $\frac{L}{f_o} \times \frac{D}{f_e}$
    Hence, to increase magnifying power, both the f_o and f_e must be small.

24. If m is pole strength, then
    $m = \frac{M}{l}$
    When the wire is bent into a semicircle arc, the separation between the two poles changes from l to 2 r, where r is radius of the semicircular arc. Since $l = \pi r$ or $r = \frac{l}{\pi}$, the new magnetic moment of the steel wire,
    $M' = m \times 2r = \frac{M}{l} \times \frac{2l}{\pi} = \frac{2M}{\pi}$

OR

i. The magnetic field of earth at any place on it can be completely described by three parameters which are called elements of magnetic field of earth. They are as follows:
   a. Angle of declination (α): Angle between magnetic meridian and geographic meridian at any place.
   b. Angle of dip (δ) or magnetic inclination: Angle between total magnetic field of earth and horizontal direction in magnetic meridian at any place.
   c. Horizontal component of earth's magnetic field (B_H): Component of earth's magnetic field in horizontal direction in magnetic meridian.

ii. At the magnetic equator, the needle shows horizontal direction, so the angle of dip is zero at the magnetic equator.

25. 

Suppose I is the real image of an object O. Let d be the distance between them. If the image distance is x, the object distance will be (d - x).

Thus, u = -(d - x) and v = +x

Substituting in the lens formula we have

$\frac{1}{x}-\frac{1}{-(d-x)}=\frac{1}{f}$

or $\frac{1}{x}+\frac{1}{(d-x)}=\frac{1}{f}$

or x^2 - xd - fd = 0

For a real image, the value of x must be real i.e. the roots of the above equation must be real. This is possible if

$d^2 \geqslant 4fd$

or $d \geqslant 4f$

Hence, 4f is the minimum distance between the object and its real image formed by a convex lens.

Section D

26. i. Suppose a rod of length 'l' moves with velocity v inward in the region having uniform magnetic field B.

Initial magnetic flux enclosed in the rectangular space is $\phi=|B| l x$

As the rod moves with velocity $-v=\frac{dx}{dt}$

Using Lenz's law,

$\varepsilon=-\frac{d\phi}{dt}=-\frac{d}{dt}(Blx)=Bl\left(-\frac{dx}{dt}\right)$

$\therefore \quad \varepsilon=Blv$

ii. Suppose any arbitrary charge 'q' in the conductor of length 'l' moving inward in the field as shown in figure, the change q also moves with velocity v in the magnetic field B.

The Lorentz force on the charge 'q' is F = qvB and its direction is downwards.

So, work done in moving the charge 'q' along the conductor of length l

W = F.l

W = qvBl

Since emf is the work done per unit charge

$\therefore \quad \varepsilon=\frac{W}{q}=Blv$

This equation gives emf induced across the rod.

27. i. The features to distinguish is given as

Interference pattern :

a. All fringes are of equal width.

b. Intensity of all bright bands is equal.

Diffraction pattern :

a. The width of central maxima is twice the width of higher order band.

b. The intensity goes on decreasing for a higher order of diffraction bands.

ii. Given, wavelength $(\lambda) = 500\text{nm} = 500 \times 10^{-9}\text{m}$

Width of single slit (d) = 0.2 mm $= 0.2 \times 10^{-3}\text{m}$

Angular width of central fringe $= 2 \times \frac{\lambda}{d}$

$= \frac{2 \times 500 \times 10^{-9}}{0.2 \times 10^{-3}} = \frac{10^{-6}}{2 \times 10^{-4}} = \frac{1}{200} = 5 \times 10^{-3}\text{radian}$

Linear width of central fringe of single slit

$= 5 \times 10^{-3} \times 10^{3}\text{mm} = 5\text{mm}$

Number of double slit fringe accommodated in central fringe $= \frac{50}{5} = 10$ fringes.

OR

i. As we know that intensity is directly proportional to the square of the amplitude(I $\propto$ a^2) and

$\frac{I_{\max}}{I_{\min}} = \frac{(\sqrt{I_1}+\sqrt{I_2})^2}{(\sqrt{I_1}-\sqrt{I_2})^2}$

Now according to question, the intensity is reduced to 50%, then

$\frac{I_{\max}}{I_{\min}} = \frac{(\sqrt{I}+\sqrt{\frac{I}{2}})^2}{(\sqrt{I}-\sqrt{\frac{I}{2}})^2} = \frac{(\sqrt{2}+1)^2}{(\sqrt{2}-1)^2} = \left(\frac{2.414}{0.414}\right)^2 = (5.83)^2 = 33.98 = 34$

ii. If the white light is used instead of monochromatic light then we see a sequence in which central fringe will be white and remaining will be coloured in VIBGYOR sequence.

28. a. In the given network, C_1, C_2 and C_3 are connected in series.(effective capacitance is small as compared to individual capacitance) The effective capacitance C' of these three capacitors is given by

$\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

For $C_1 = C_2 = C_3 = 10\ \mu F$, $C' = (\frac{10}{3})\ \mu F$. The network has C' and C_4 connected in parallel.

Thus, the equivalent capacitance C of the network is

$C = C' + C_4 = \left(\frac{10}{3} + 10\right) \mu F = 13.3 \mu F$

b. Clearly, from the figure, the charge on each of the capacitors, C_1, C_2 and C_3 is the same, say Q. Let the charge on C_4 be Q'. Now, since the potential difference across AB is $\frac{Q}{C_1}$, across BC is $\frac{Q}{C_2}$, across CD is $\frac{Q}{C_3}$, we have

$\frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$ = 500 V

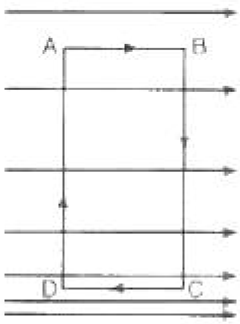
Also, $\frac{Q'}{C_3}$ = 500 V

This gives for the given value of the capacitances.

Q = $500V \times \frac{10}{3}\mu F = 1.7 \times 10^{-3}$ C and Q' = 500 V $\times$ 10 μF = 5.0×10^{-3} C

OR

Suppose that a charge q is moved along a closed path ABCD inside the electric field [In a figure]. Since work done to move a charge q along a closed path inside an electric field is zero,



$W_{AB} + W_{BC} + W_{CD} + W_{DA} = 0$ ....(i)

Since electric field is perpendicular to paths BC and DA,

$W_{BC} = W_{DA} = 0$

Therefore, the equation (i) becomes

$W_{AB} + 0 + W_{CD} + 0 = 0$

or $W_{AB} = -W_{CD}$

But for the electric field shown in Figure, work done to move a charge along the paths AB and CD can not be equal in magnitude. As the lines of force are closer to each other near the path CD, intensity of electric field is more along the path CD than along the path AB. Therefore, work done to move the change q along the path CD will be more than that along the path AB. Thus, work done to move a charge along a closed path cannot be zero for the electric field as shown in the figure and hence, it is impossible to produce an electric field shown in the figure.

29. i. The three experimentally observed features in the phenomenon of photoelectric effect are -

a. Threshold frequency: The photoelectric effect will occur when the incident frequency is greater or equal to the threshold frequency for a given metal i.e $\nu \geq \nu_0$.
b. The maximum kinetic energy of photoelectron: When the incident frequency is greater than the threshold frequency, the maximum kinetic energy is proportional to $\nu - \nu_0$.
c. No time lag: When energy of incident photon is greater than the work function, the photoelectron is immediately ejected. Thus, there is no time lag between the incidence of light and emission of photoelectron.

ii. We can not explain these by using wave theory of light because there are following reasons-
a. The instantaneous ejection of photoelectrons.
b. The existence of threshold frequency for a metal surface.
c. The kinetic energy of photoelectrons is independent of the intensity of light and depends on its frequency.

30. i. Given, N = 30, I = 6.0 A, B = 1.0 T, α = 60°
r = 8.0 cm = $8 \times 10^{-2} m$
Area of the coil, $A = \pi r^2$
$= \frac{22}{7} \times (8 \times 10^{-2})^2$
$A = 2.01 \times 10^{-2} m^2$
Now, $\tau = NBIA \sin \alpha$
$= 30 \times 6.0 \times 1.0 \times (2 \times 10^{-2}) \times \sin 60^\circ$
$\tau = 30 \times 6 \times 1 \times 2 \times \frac{\sqrt{3}}{2} \times 10^{-2} = 3.12 Nm$

ii. Since the torque on the planar loop does not depend upon the shape, in case the area of the loop is the same, the torque will remain unchanged.ape.

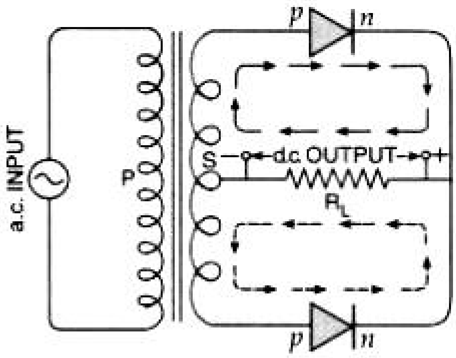
Section E

31. **Junction Diode as a Rectifier:** An electronic device which converts a.c. power into d.c. power is called a rectifier. The junction diode offers a low resistance path when forward biased; and a high resistance path when reverse biased. This feature of the junction diode enables it to be used as a rectifier.

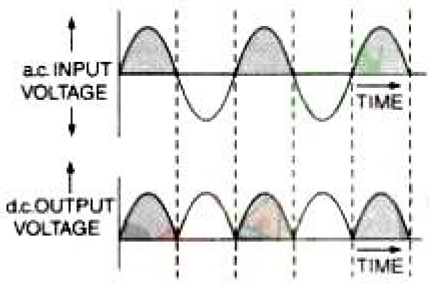
Full-wave Rectifier:

A rectifier which rectifies both halves of each a.c. input cycle is called a full-wave rectifier. To make use of both the halves of input cycle, two junction diodes are used.

The circuit arrangement is shown in the figure.



Suppose that during first half of the input cycle, upper end of coil S is at positive potential and the lower end is at negative potential. The junction diode D_1 will get forward biased, while the diode D_2 reverse biased. The conventional current due to the diode D_1 will flow along the path of full arrows. When the second half of the input cycle comes, the situation will be exactly reverse. Now, the junction diode D_2 will conduct and the conventional current will flow along the path of the dotted arrows. Since current during both the half cycles flows from right to left through the load resistance R_L, the output during both the half cycles will be of the same nature. The right end of the load resistance R_L will be at positive potential w.r.t. its left end. The magnitude of output across R_L at any time will vary in accordance with the a.c. input as shown in Fig. Thus, in a full wave rectifier, the output is continuous but pulsating in nature. However, it can be made smooth by using a filter circuit.



OR

i. LED is a forward-biased p-n junction diode which converts electrical energy into optical energy of infrared and visible light region.

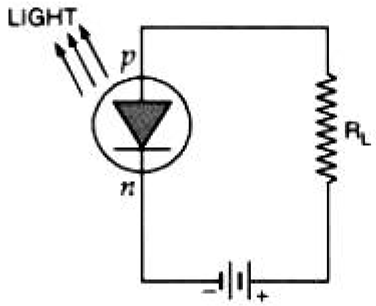


Fig. shows a LED in forward bias. As there is very little resistance to limit the current in a LED, therefore, a resistor (R) is used in series with the LED to avoid any damage to it. The junction acts as a barrier to the flow of electrons between the p and the n-regions. Only when sufficient voltage is applied to the LED, the electrons cross the junction into the p-region. Once in the p- region, the electrons are immediately attracted to the positive holes. When an electron moves sufficiently close to the hole in the p - region, they recombine. Each time, an electron recombines with a positive hole, electric potential energy is converted into electromagnetic energy and a photon of light with a frequency characteristic of the semiconductor material is emitted. In forward bias, more is the applied voltage, more is the current and hence more is the intensity of the emitted light.

ii. The semiconductor used for fabrication of visible LEDs must at least have a band gap of 1.8 eV. $GaAs_{0.6}P_{0.4}$ (E_g ~ 1.9 eV) is used for red LED. GaAs (E_g~ 1.4 eV) is used for making infrared LED.

LEDs have the following advantages over conventional incandescent low power lamps:

(a) Low operational voltage and less power.

(b) Fast action and no warm-up time required.

32. i. To draw maximum current from a series L-C-R circuit, the circuit should have the lowest impedance that means $X_L = X_C$

$\Rightarrow \omega L = \frac{1}{\omega C}$

$\Rightarrow \omega^2 = \frac{1}{LC}$

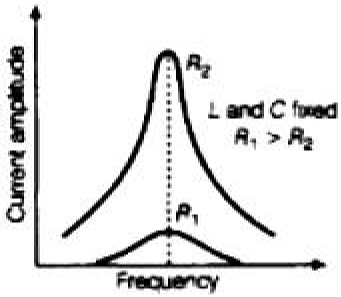
$\Rightarrow \omega = \frac{1}{\sqrt{LC}}$

$\Rightarrow 2\pi f = \frac{1}{LC}$

$\Rightarrow f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\times3.14\sqrt{8\times2\times10^{-6}}} = 39.80\text{Hz}$

This frequency is known as the series resonance frequency.

ii. $I_0 = \frac{V}{R} = \frac{200}{100} = 2A$

iii. 

iv. The sharpness of resonance is the defined as Q factor, which relates how fast energy is decayed in an oscillating system.

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

It may also be defined as the ratio of resonance angular frequency to the bandwidth of the circuit,

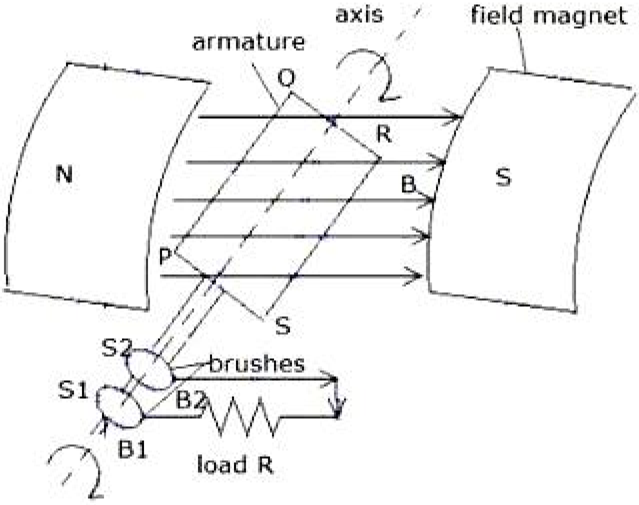
$$Q = \frac{\omega_r}{2\Delta\omega}$$

If the resonance is less sharp, not only is the maximum current less, the circuit is close to resonance for a larger range $\Delta\omega$ of frequencies and the tuning of the circuit will not be good. So, less sharp the resonance, less is the selectivity of the circuit or vice versa. Thus, we see that if quality factor is large, i.e., R is low or L is large, the circuit is more selective.

OR

The working of an ac generator is based on the principle of electromagnetic induction. When a closed coil is rotated in a uniform magnetic field with its axis perpendicular to the magnetic field, the magnetic flux linked with the coil changes and an induced emf and hence current is set up in it.

Working and Theory: As the armature coil is rotated in the magnetic field, the angle θ between the field and normal to the coil changes continuously. Therefore, magnetic flux linked with the coil changes. An emf is induced in the coil. According to Fleming's right-hand rule, current induced in AB is from A to B and itis from C to D in CD. In the external circuit, current flows from B_2 to B_1.



Let N = number of turns in the coil, A = face area of each turn, B = magnitude of the magnetic field, θ = angle which normal to the coil makes with filed B, ω = the angular frequency with which coil rotates

Then the magnetic flux linked with the coil at any instant t will be,

$\varnothing$ = NBA cosθ = NBA cos ωt

By Faraday's flux rule, the induced emf is given by

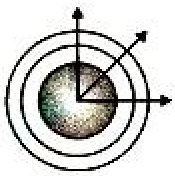
$$\epsilon = -\frac{d\varnothing}{dt} = -\frac{d}{dt}(NBA\cos\omega t) = NBA\omega\sin\omega t$$

$\epsilon = \epsilon_0 \sin\omega t$

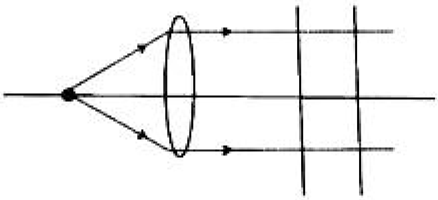
where $\epsilon_0 = NBA\omega$

33. i. A wave front is defined as a surface of constant phase. The ray, at each point of a wave front, is normal to the wave front at that point. The ray indicates the direction of propagation of wave while the wave front is the surface of constant phase.

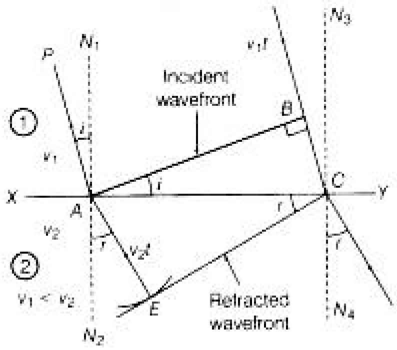
ii. a. In case of light diverging from a point source, the shape of wave-front is a spherical as shown in the figure:



b. In case of light emerging out of a convex lens when a point source is placed at its focus, the wave-front is a plane wave front as shown below:



c. The following diagram shows the passage of a plane wavefront from a denser into a rarer medium.

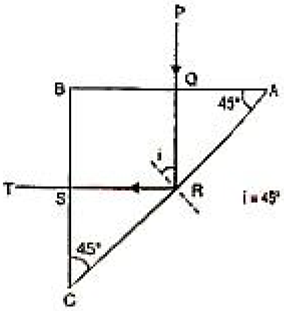


then, $BC = v_1 t$ ...(i)

OR

i. ABC is the section of the prism, B is a right angle. A and C are equal angles i.e. A = C = 45°.

The ray PQ is normally incident on the face AB. Hence it is normally refracted and the ray QR strikes the face AC at an angle of incidence 45°. It is given that the ray does not undergo refraction but is totally reflected at the face AC. This gives a maximum value for the critical angle as 45°.



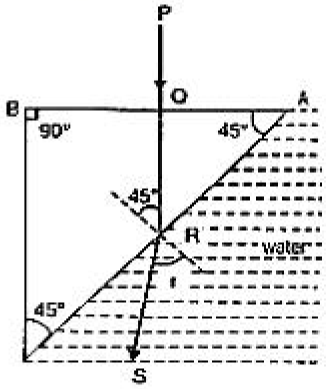
sin C = sin 45° $= \frac{1}{\sqrt{2}}$ in the limit

Since $\mu = \frac{1}{\sin C} = \frac{1}{\sqrt{2}}$

or, $\mu = \frac{1}{\sin 45}$ *or* $\mu_{\min} = \sqrt{2}$

The minimum value of refractive index $= \sqrt{2}$.

ii. When the prism is immersed in water the critical angle for the glass water interface is given by



$$\sin C_1 = \frac{4/3}{\sqrt{2}} = \frac{4}{3\sqrt{2}}$$

C_1 = 70.53°

The angle of incidence at R continues to be 45° and since 45° < 70.53°, refraction taking place and the refracted ray is RS. The angle of refraction r is given by

$$\mu_g \sin i = \mu_w \sin r$$

$$g\mu_\omega = \frac{\sin i}{\sin r}$$

$$\frac{\mu_\omega}{\mu_g} = \frac{\sin i}{\sin r}$$

$$\sqrt{2}\sin 45^\circ = \frac{4}{3}\sin r$$

$$\sin r = \frac{3\sqrt{2}}{4}\sin 45^\circ = \frac{3\sqrt{2}}{4} \times \frac{1}{\sqrt{2}} = \frac{3}{4}$$

$$r = \sin^{-1}\frac{3}{4} = 48^\circ 36'$$

$\therefore$ The angle of refraction in water = $48^\circ 36'$